xiv. Quench Detection System

The RHIC quench detection system monitors various types of superconducting magnets, shunt bus and gas cooled leads continuously to sense magnet quenches and gas cooled lead faults. The method to detect quenches is by voltage sensing, as shown in Fig.2-25 RHIC Quench Detection System Block Diagram. When a quench is determined, the system sends a quench signal for the power supplies to shutdown and energy extraction system to operate, thus protecting all essential parts of the RHIC magnet circuit.

This is a distributed system, it separates into twelve subsystems. Six subsystems located at service buildings and the other six subsystems located at "B" alcoves throughout the ring. Each subsystem is a standalone unit that processes its data locally. All subsystems are networked together via the Ethernet, as shown in Fig. 2-26 RHIC Quench Detection System Layout. The Control System passes Ring Events, RTDL and other parameters to the Quench System Crate controller. Data from subsystems are routed to a concentrator and archived periodically or at the time of a quench. Another PC base system containing the analysis and plotting software is also networked, allowing remote monitoring, analysis and troubleshooting of various components.

Subsystems in alcoves monitor arc-region Dipole, Quadrupole magnet voltage taps. Subsystems at service buildings monitor insertion-region magnets, shunt bus voltage taps, gas cool leads and power supply currents. Each subsystem is divided into three functional sections. The front-end computer section, ADC/timing-control section, and the low level hardware interface section.

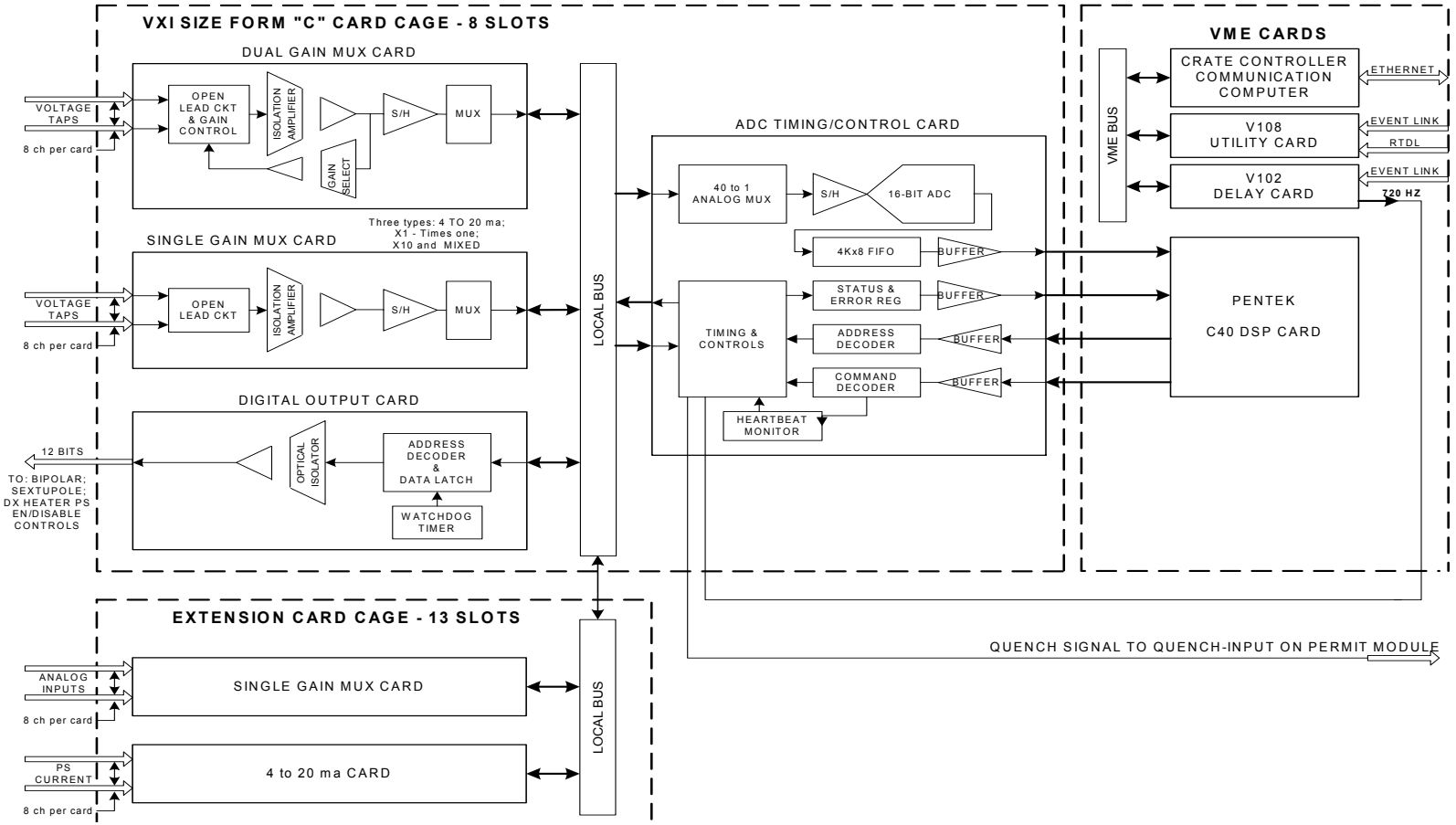

Fig. 2-25 RHIC Quench detection System Block Diagram

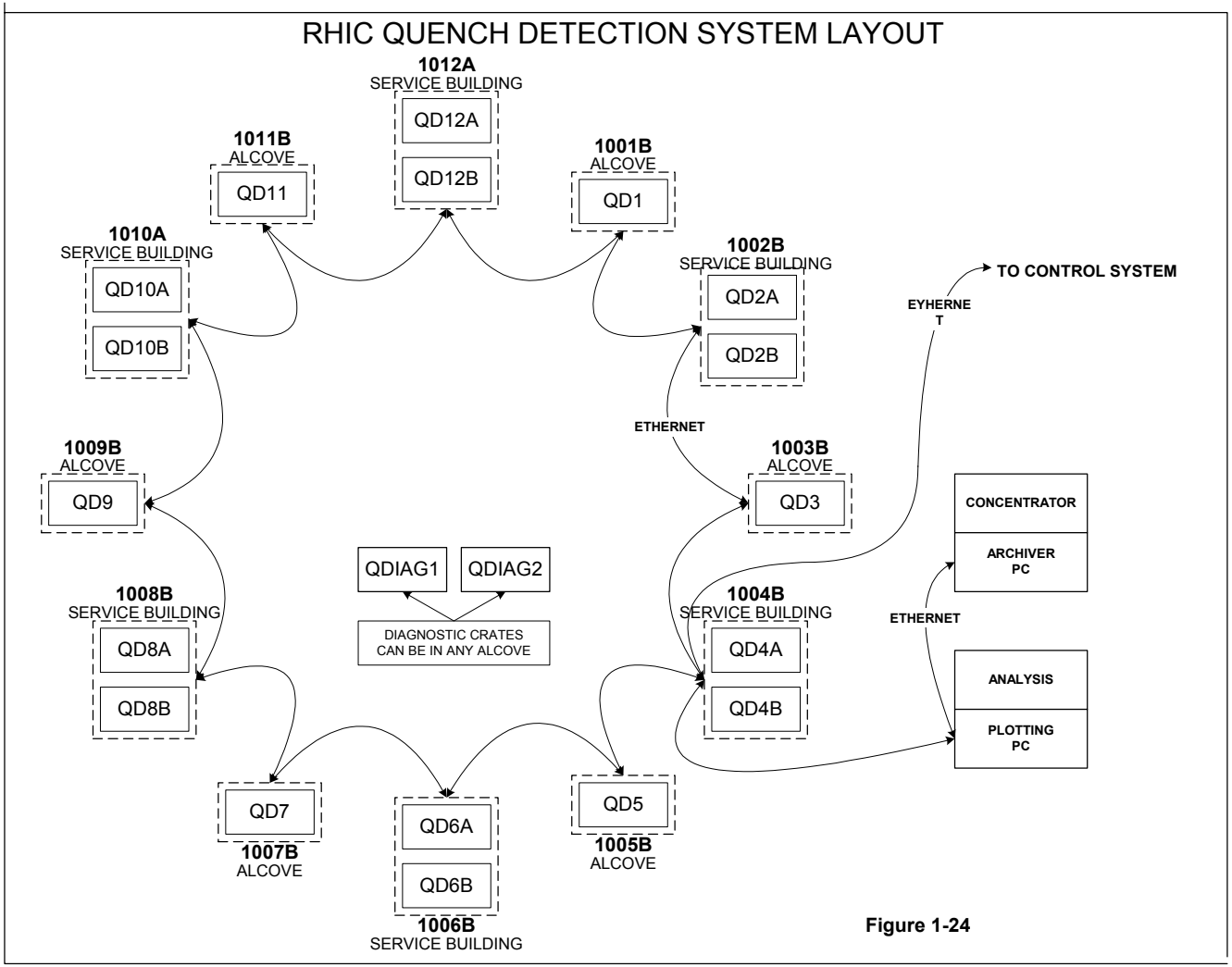

Fig. 2-26 RHIC Quench detection System Layout

The front-end computer section consists of a VME Crate controller, an Utility card, a Delay card and a DSP card. The function of the Crate controller is to communicate with the Control System, download programs and parameters, upload stored data to users and initialize other VME modules. The Utility card extracts Magnet Currents from the Real Time Data Link (RTDL) and passes them the DSP card. The Delay card decodes events from the Event Link and synchronizes the Quench Detection System to the 720Hz master clock at the Control system. The function of the DSP card is to read the magnet currents from the Utility card, current readback from the 4-to-20 ma card, and the magnet voltage taps signals from the analog-to-digital converter card once every 1.389ms. Noise component of 60Hz is removed by averaging twelve acquired samples. Quench condition is determined by performing calculations based on the $Vc(t) = Rc(t) * i(t) + Lc(di/dt)$ formula. Since the gas cooled lead has no resistance nor inductance, its fault is determined by comparing the voltage readback to a fixed threshold value. If the calculated Vc(t) or the gas cool lead readback voltage is outside the band of the expected value that stored in the database, fault is determined. The DSP card then sends a quench signal to the Quench input of the Beam Permit Module via the ADC Card to shutdown power supplies and activate the energy extraction system.

The ADC/timing-control Card generates a simultaneously sample-and-hold signal to all low-level interface cards at the rate of 720 Hz. The holding analog signals are converted by a 16-bit scanning ADC at a fixed rate of about 10μs per channel. Converted data and hardware status are sent to a FIFO that allows the DSP to fetch data at rate up to 80ns. There is a one-second watchdog timer on the ADC card. If this timer is not reset by the DSP software, indicating the software is working properly, then the ADC card will send out the quench signal to shutdown.

There are four different types of analog interface cards to accommodate different input signals. Each card has eight analog input channels and contains open-circuit detection circuitry. The circuit sends a small negative dc current to each voltage tap. If the voltage tap or the wires to the tap are not open, then the readback is around zero volt. When the tap or the wires to the tap break or open, the sensing voltage changes to negative. This fault is sensed and reported by the DSP card to warn users that the tap is not connected correctly. The Dual Gain Mux Card connects to the Dipole and Quadrupole Magnet voltage taps. It has a gain of 0.5 in the normal mode for signals up to ±20 volts, the card automatically switches to a gain of 0.025 during

quench for signals up to ±400 volts. The Single Gain Mux Card has three different versions. The X1 version accepts signals up to ±10 volts, the X10 version accepts signals up to ±1 volt, and the 4-to-20 mA version that connects to Insertion Power Supplies. There is one type of Digital Output Card to enable or disable the Bipolar, Sextupole, and DX Quench Heater power supplies. To protect the DX magnet further with hardware protection, the Digital Output card has a 20ms watchdog timer onboard. If this timer is not reset by the DSP software at the rate of less than 20ms, then the Digital Output Card will trigger the DX Heater Power Supplies and quench the DX magnet.